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㊹発明の名称　電気泳動表示装置及びその製造法

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明　細　書

1．発明の名称

電気泳動表示装置及びその製造法

2．特許請求の範囲

(1) 少なくとも一方が透明な一組の対向電極板間に電気泳動粒子を含む分散系を封入し、該電極板間に印加した表示制御用電圧の作用下に分散系内の電気泳動粒子の分布状態を変えることにより光学的反射特性に変化を与えて所要の表示動作を行わせるようにした電気泳動表示装置に於いて、上記分散系を不連続に分割する手段として上記電極板間に介装した弾性質多孔性スペーサを備え、上記対向電極板の一方を可撓性シートで構成すると共に、他の電極板を剛体で構成したことを特徴とする電気泳動表示装置。

(2) 前記可撓性シート電極板の基材をフィルム部材で構成し、上記剛体電極板の基材を透明ガラス板で構成した請求項(1)の電気泳動表示装置。

(3) 前記弾性質多孔性スペーサはその端部周域に上記両電極板との接着固定部を有する請求項(1)又は(2)の電気泳動表示装置。

(4) フィルム部材及び透明ガラス板の各一方面に所要の電極パターンを各々形成した可撓性電極板と透明な剛体電極板とを用意し、該剛体電極板の電極パターン側に配装した弾性質多孔性スペーサに対し電気泳動粒子を分散させた分散系を過剰に供給した後、上記可撓性電極板をその電極パターンが上記剛体電極板の電極パターンと対面するように上記弾性質多孔性スペーサ上に配装し、次に上記可撓性電極板の上面に加圧部材を配置してこの可撓性電極板を上記弾性質多孔性スペーサに密着させて余分な分散系を押し出すと共に該弾性質多孔性スペーサを圧縮してその各孔に上記分散系を封入し、該封入分散系を上記弾性質多孔性スペーサの復元力により負圧状態に保持することを特徴とする電気泳動表示装置の製造法。

(5) 前記加圧部材又は加圧力付与手段に、気体、液体又は固体の少なくとも一つを使用する請求項(4)の電気泳動表示装置の製造法。

(6) 前記弾性質多孔性スペーサの端部周域に上記可撓性電極板に対する接着固定部を形成するようにした請求項(4)又は(5)の電気泳動表示装置の製造法。

3. 発明の詳細な説明

「産業上の利用分野」

本発明は電気泳動粒子を利用した表示装置に於いて、一方の電極板に樹脂製フィルム等からなる可撓性基材を用いることにより、分散系を小区間に不連続相に分割する為の弾性質多孔性スペーサの各孔に分散系を確実に封入できるように構成した電気泳動表示装置及びその製造法に関する。

「従来の技術」

電気泳動粒子を利用したこの種の電気泳動表示装置は、第3図の如く、対向面に各々酸化インジウム・スズ等の適宜な透明導電部材を用いて所要の表示用電極パターン2、4を各別に形成した二枚の透明ガラス板1、3を設け、液体分散媒に電気泳動粒子6を分散させた分散系7をその対向間隙間に封入すべくスペーサ機能を兼ねる封止部材5を外周部位に配装した構造を有する。このような構造の電気泳動表示装置は、電極パターン2、4に表示駆動用電圧を印加して電気泳動粒子6を電極パターン2、4に吸着・離反させ得るように分散系7に電界を作用させて電気泳動粒子6の分布状態を変えるとこにより分散系7の光学的特性に変化を与えて文字、記号又は図形等の所望の表示動作を行わせるものである。

分散系7の封入態様として上記の如く端部に設けた封止部材5によって連続相状に構成する場合には、両電極パターン2、4間の間隔むら等による電界強度の不均一に起因して電気泳動粒子6が電極パターン面と平行方向な移動を起こして電気泳動粒子の濃度分布に偏りを生じ、その結果この電気泳動表示装置を長時間繰返し使用すると電気泳動粒子の濃度が場所的に不均一になったり表示むらを発生するという問題がある。

そこで、このような不都合を解消する手段として、第4図の如く、多数の透孔を備えた多孔性スペーサ8を用いて各透孔に分散系を封入し、以って分散系7を小区間に不連続相に分割するような構造も特開昭49-32038号、特開昭59-34518号又は特開昭59-171930号各公報等で知られている。

「発明が解決しようとする課題」

しかし、多孔性スペーサを用いて分散系を小区間に不連続相に分割する分散系分割型の電気泳動表示装置に係る上記先行技術に於いて、両電極板に各々基板フィルムを使用する場合には、フィルムの変形等によって多孔性スペーサと電極板間に間隙を生じ易いので、電気泳動粒子の偏在を発生させる虞がある。また、双方ともガラス板の基材で両電極板を構成する場合には、ガラス板の平面性と多孔性スペーサの厚みの分布の関係により、多孔性スペーサと電極板間に隙間を残す部分を発生し、斯かる構造の場合でも電気泳動粒子の偏在を防止することは容易ではない。

更に、両電極板と介装多孔性スペーサとを予め接着したセル構造のものでは、多孔性スペーサの各孔に分散系を一様に注入することは非常に困難である等、分散系注入処理に伴なう製造上の難点が種々存在する他、分散系注入の不完全な部分が発生して表示欠陥となる虞が多分にあり、信頼性の高い表示装置を得る上での解決課題は多い。

「課題を解決するための手段」

本発明は、多孔性スペーサを用いる分散系分割型の電気泳動表示装置に於いて、多孔性スペーサを弾性質部材で構成すると共に、電極板の一方を可撓性に構成することにより、弾性質多孔性スペーサの各孔に分散系を容易確実に注入可能な電気泳動表示装置及びその製造法を提供するものである。

その為に、本発明の電気泳動表示装置では、少なくとも一方が透明質に構成された一組の対向配置した電極板間に多孔性スペーサを介して電気泳動粒子を分散させた分散系を不連続相に分割して封入する構造の電気泳動表示装置に於いて、上記多孔性スペーサを弾性質部材で形成すると共に、上記一方の電極板を該弾性質多孔性スペーサに対して密着可能な可撓性に構成し、且つ上記他方の

電極板を透明質剛体で形成し、上記弾性質多孔性スペーサに於ける分散系を該スペーサの弾性により負圧に保持させるように上記可撓性電極板をこの弾性質多孔性スペーサの各透孔側に部分的に撓ませるべく構成したものである。

斯かる電気泳動表示装置を製作するには、先ずフィルム部材及び透明ガラス板の各一方面に所要の電極パターンを各々形成した可撓性電極板及び透明な剛体電極板を用意し、該透明剛体電極板の電極パターン側に配装した弾性質多孔性スペーサに電気泳動粒子を分散させた分散系を過剰に供給した後、上記可撓性電極板をその電極パターンが上記剛体電極板の電極パターンと対面するように上記弾性質多孔性スペーサ上に配装し、次に上記可撓性電極板の上面側に加圧力を作用させて上記弾性質多孔性スペーサの圧縮状態で該可撓性電極板をこの弾性質多孔性スペーサに密着させて余分な分散系を押し出して該多孔性スペーサの各孔に分散系を封入し、上記弾性質多孔性スペーサ自体の復元力により封入分散系を負圧状態に保持する手法が採用される。

このような電気泳動表示装置を製造する際には、シリコンゴム、ウレタンゴム、フッ素ゴム、アクリルゴム等の合成ゴムや天然ゴム等で形成可能な弾性質多孔性スペーサを上記透明剛体電極板に予め一体に形成することも好適な手法である。

「実　施　例」

以下、図示の実施例を参照しながら本発明を更に詳述する。第一図に於いて、10は透明な剛体電極板を構成する為の基材としての透明なガラス板であってその上面には酸化インジウム・スズ等の透明導電材料を用いて所要の電極パターン11を適宜形成してある。この剛体電極板の上面には分散系を小区間に分割して封入するための弾性質多孔性スペーサ12を配装してある。この多孔性スペーサ12は、シリコンゴム、ウレタンゴム、フッ素ゴム、アクリルゴム等の合成ゴムや天然ゴム等の素材からなるシート状物にパンチ、レーザ等の手段で所要の透孔を多数穿設したものをこの剛体電極板の電極パターン11形成側に一体的に設けるか、若しくは感光性樹脂を該電極パターン11上に被着形成してエッチング等の化学的溶解手段で所要の透孔を任意形成し得る。

弾性質多孔性スペーサ12は、第2図の如く、分散系の分割封入の為の上記態様で形成され得る多数の透孔12Bを有する他、該スペーサ12の端部周域には後述の可撓性電極板との関連に於いて、透孔12Bを設けない斜線で示す接着固定部12Aを形成するのが好適である。斯かる弾性質多孔性スペーサ12の上面には上記電極パターン11と対向する面に他の電極パターン14を形成したフィルム基材13からなる可撓性電極板を配装してある。15は加圧部材を示し、これは弾性質多孔性スペーサ12の各孔12Bに過剰に供給した分散系7を可撓性電極板の上面から押圧するして該スペーサ12を圧縮しながら余分な分散系7を押し出すことにより、弾性質多孔性スペーサ12の各孔12Bに空孔のない分散系7の完全な封入を行なわせる為のものである。この加圧部材15には、気体、液体又は固体の少なくとも一つを適宜使用できるものであるが、図示の場合では鋼製ロールを用いた例を示す。なお、16は構成部材間をそれらの端部で固定接合する為の接着剤を示す。

上記構造の分散系分割型の電気泳動表示装置を製作するには、透明ガラス板10及び透明電極パターン11で構成された剛体電極板の該電極パターン11上に第2図に示すような弾性質多孔性スペーサ12を形成した後、表示目的に最適な如く適宜な液体分散媒に酸化チタン等の電気泳動粒子を分散させて予め調製した分散系7を弾性質多孔性スペーサ12に所要量以上に過剰に供給して該スペーサ12をこの分散系7で完全に覆っておく。次いで、可撓性電極板をその電極パターン14が剛体電極板の電極パターン11と対面するように弾性質多孔性スペーサ12に重ね合わせた状態で可撓性電極板の上面側に加圧部材としての鋼製ロール15を配置する。このロール15による可撓性電極板の一端部からの順次的な弾圧力の付与により、可撓性電極板は弾性質多孔性スペーサ12

に十分に押し付けられて密着する。これにより、弾性質多孔性スペーサ１２に対し過剰に供給された余分な分散系は該スペーサ１２の各孔１２Ｂから押し出され、また、鋼製ロール１５の弾圧付力によって弾性質多孔性スペーサ１２の圧縮状態で分散系７がその各孔１２Ｂに封入されることとなる。そして、接着剤１６を用いて剛体電極板、弾性質多孔性スペーサ１２及び可撓性電極板の各外周端部を相互に接着固定すると、弾性質多孔性スペーサ１２の復元力によって分割封入済分散系７は該スペーサ１２の各孔１２Ｂ内で負圧状態に保持され、以って空孔のない分割型分散系の完全な封入処理を容易迅速に施すことが出来る。

ここで、弾性質多孔性スペーサ１２は、シート状に形成したシリコンゴム等を用いて、打抜き、ドリル穿孔又はレーザ加工等の手段で所要の透孔を多数形成した後、熱プレス等の手段でその厚さを両電極板の間隙以下となるように適宜成形可能である。また、このスペーサ１２の各透孔１２Ｂの形状は、角状又はスリット状等の他、円状や矩形状又は多角形状など任意に定めることができ、その配列も規則的又は不規則的に設け得る。斯かる弾性質多孔性スペーサ１２の厚さは、シリコンゴム又はウレタンゴムなど使用すべき部材の復元率、分散媒の組成や両電極板間の間隙等を考慮して適宜選定できるが、一般的には２０μｍ～１ｍｍ程度に定めることができる。

分散系７に用いる電気泳動粒子は、周知の各種のコロイド粒子のほか、種々の有機、無機質顔料、染料、セラミックス若しくは樹脂等の微粉末などを適宜使用できる。また、分散系７の分散媒としては、炭化水素、ハロゲン化炭化水素、芳香族炭化水素等の他、天然又は合成の各種の油等を任意使用できる。そして、分散系７には必要に応じ、電解質、界面活性剤、金属石けんや樹脂、ゴム、油、ワニス、コンパウンド等の粒子からなる荷電制御剤に加え、分散剤、潤滑剤、安定化剤などを適宜添加できる。更に、電気泳動粒子の荷電を正又は負に統一したり、ゼータ電位を高める手段のほか、電気泳動粒子の電極パターン１１、１４に対する吸着性や分散媒の粘度等の調整も適宜行える。

一実施例に於いて、フィルム基材１３及び透明ガラス板１０の各一方面に酸化インジウム・スズを使用して各々所要の透明な電極パターン１１、１４を各別に形成した可撓性電極板と剛体電極板とを用意し、その剛体電極板の電極パターン１１の形成側に多数の透孔を有するシリコンゴムシートを配装して第２図の如き構造の弾性質多孔性スペーサ１２を形成した。

一方、分散系７の為の分散媒として、ヘキシルベンゼン100 ccを用意し、これにオイルブルーBAからなる濃紺の染料1ｇとシルバンS83からなる界面活性剤0.5ｇとを溶かし、この溶媒に電気泳動粒子として酸化チタン5ｇを分散させて分散系７を調製した。この分散系７を空気が残らないように弾性質多孔性スペーサ１２に過剰に注いでこのスペーサを完全に覆った。次に、可撓性電極板を第１図の如くこの弾性質多孔性スペーサ１２上に配置した上、該可撓性電極板の表面側に鋼製ロール１５を用いてその一端から順次加圧押圧力を作用させることにより、可撓性電極板を弾性質多孔性スペーサ１２に密着させながら余分な分散系７を押し出す一方、該スペーサ１２の圧縮状態でその各透孔１２Ｂに分散系を完全に封入した後、該スペーサ１２と密着した可撓性電極板に於ける端部周域をクランプした。最後に、このクランプ部分に於いて両電極板及び弾性質多孔性スペーサ１２を含む構成部材の端部間をエポキシ系接着剤１６で接着固定し、第１図に示すような分散系７を負圧状態で小区間に分割して封入した電気泳動表示装置を得た。

この電気泳動表示装置の電極板間に直流70 Vの電圧を反復的に印加してスイッチング試験を行ったところ、1000万回のスイッチング経過後に於いても電気泳動粒子の偏りは認められず、コントラストの良好な表示動作を得た。

「発明の効果」

本発明による電気泳動表示装置は、多孔性スペーサを使用して分散系を小区間に不連続相に分割

して封入する構造の電気泳動表示装置に於いて、多孔性スペーサを弾性質のものに構成し、電極板の一方を可撓性に構成したので、斯かる表示装置を製作する場合には、分散系を過剰に供給した弾性質多孔性スペーサ上に可撓性電極板を配装した状態でこの可撓性電極板側に加圧押圧力を順次作用させることにより、可撓性電極板を弾性質多孔性スペーサに密着させながら余分な分散系を押し出し、該スペーサの圧縮状態で弾性質多孔性スペーサの各透孔に空孔を残すことなく容易に分散系を完全に封入できる。

そして、弾性質多孔性スペーサの復元力によりその各透孔に封入された分散系は負圧状態で封入保持できる。

斯かる電気泳動表示装置は、その構成が簡易であって、弾性質多孔性スペーサの各透孔に分散系を完全に封入する手法として格段なものがある。

従って、表示欠陥のないコントラストの良好な表示信頼性の高い優れた分散系分割型の電気泳動表示装置を提供できる。

4．図面の簡単な説明

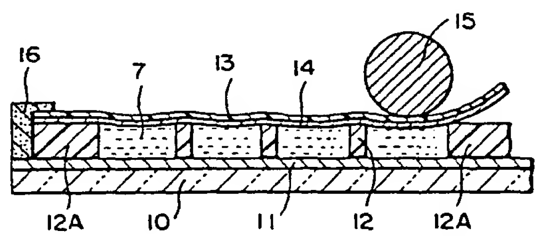
第1図は本発明の一実施例に従って構成された透明剛体電極板に設けた弾性質多孔性スペーサと可撓性電極板とを具備する分散系分割型の電気泳動表示装置に於いて、弾性質多孔性スペーサの各孔に分散系を封入処理する手法として弾性質多孔性スペーサに過剰の分散系を供給して可撓性電極板の配置後、この可撓性電極板側に加圧力の作用下に分散系を封入する説明図、

第2図は本発明の手法により透明剛体電極板の電極パターン形成側に外周部の接着固定部と共に形成した弾性質多孔性スペーサの概念的な部分拡大平面構成図、

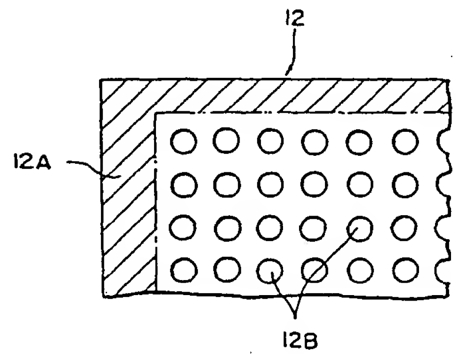
第3図は多孔性スペーサを使用しない従来の構造による分散系連続相型の電気泳動表示装置の概念的断面構成図、そして、

第4図は多孔性スペーサを備えた従来構造の分散系分割型電気泳動表示装置をその分散系の注入に伴なう問題点と共に示す概念的断面構成図である。

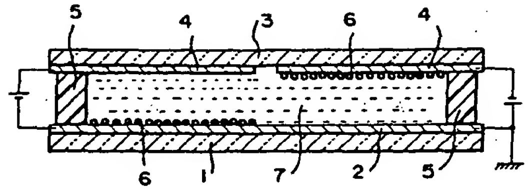
1，3：透明ガラス板
2，4：電極パターン
5：端部スペーサ
6：電気泳動粒子
7：表示用分散系
8：多孔性スペーサ
10：透明ガラス板
11：電極パターン
12：弾性質多孔性スペーサ
12A：接着固定部
12B：多数の透孔
13：フィルム基材
14：電極パターン
15：鋼製ローラ
16：固定用接着剤



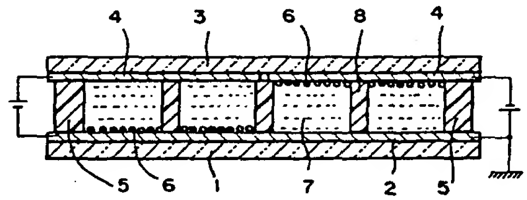

第1図




第2図




第3図




第4図

第1頁の続き
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(54) **Title of the Invention**: Electrophoretic Display Device, and Manufacturing Method Thereof

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## SPECIFICATION

### 1. Title of the Invention

Electrophoretic Display Device, and Manufacturing Method Thereof

### 2. Claims

(1) An electrophoretic display device, wherein a disperse system containing electrophoretic particles is sealed between a set of opposing electrode plates at least one of which is transparent, and the optical reflection characteristics thereof are modified and the desired display operation is enabled by changing the distribution state of the electrophoretic particles in the disperse system under the action of a display control voltage applied between the electrode plates, said electrophoretic display device being characterized in that an elastic porous spacer

interposed between the electrode plates is provided as a means for dividing the disperse system in a discontinuous manner, one of the opposing electrode plates is composed of a flexible sheet, and the other electrode plate is composed of a rigid body.

(2) The electrophoretic display device according to claim (1), wherein the substrate of the flexible electrode plate is composed of a film member, and the substrate of the rigid electrode plate is composed of a transparent glass plate.

(3) The electrophoretic display device according to claim (1) or (2), wherein the elastic porous spacer has a portion that allows the spacer to be bonded and affixed to the two electrode plates along the peripheral edge thereof.

(4) A method for manufacturing an electrophoretic display device, characterized in that a flexible electrode plate and a transparent rigid electrode plate obtained by forming the desired electrode pattern on one side of a film member and transparent glass plate, respectively, are prepared; a disperse system containing dispersed electrophoretic particles is fed in excess to a flexible porous spacer disposed on that electrode pattern side of the rigid electrode plate; the flexible electrode plate is mounted on the elastic porous spacer such that the electrode pattern thereof faces the electrode pattern on the rigid electrode plate; a pressure member is mounted on the top surface of the flexible electrode plate; the flexible electrode plate is brought into close contact with the elastic porous spacer to force out excess disperse system; and the elastic porous spacer is compressed to seal the disperse system in the pores thereof and to keep the sealed disperse system in a state of negative pressure by the restoring force of the elastic porous spacer.

(5) The method for manufacturing an electrophoretic display device according to claim (4), wherein at least one of gas, liquid, and solid is used as the pressure member or pressure application means.

(6) The method for manufacturing an electrophoretic display device according to claim (4) or (5), wherein the peripheral edge region of the elastic porous spacer is provided with a portion that allows the spacer to be bonded and affixed to the flexible electrode plate.

## 3. Detailed Description of the Invention

### (Field of Industrial Utilization)

The present invention relates to a display device featuring electrophoretic particles, wherein this electrophoretic display device is configured such that a disperse system can be securely sealed in the pores of an elastic porous spacer used to divide the disperse system into a discontinuous phase among cells by the use of a flexible substrate composed of a resin film or the like for one of the electrode plates; and also relates to a manufacturing method thereof.

### (Prior Art)

An electrophoretic display device featuring such electrophoretic particles comprises two transparent glass plates 1 and 3 on which display electrode patterns 2 and 4 are separately formed on the facing surfaces thereof from tin/indium oxide or another transparent electrode member, and further comprises a sealing member 5 disposed on the external periphery thereof, wherein this sealing member is additionally provided with spacer functions and is used to seal a disperse system 7 (obtained by dispersing electrophoretic particles 6 in a liquid dispersion medium) in the gap between the facing surfaces, as shown in Fig. 3. In the electrophoretic display device thus configured, the optical characteristics of the disperse system 7 are modified and the desired display operation (displaying characters, symbols, diagrams, or the like) is enabled by applying a display drive voltage to the electrode patterns 2 and 4, creating an electric field in the disperse system 7, and changing the distribution state of the electrophoretic particles 6 to allow the electrophoretic particles 6 to be adsorbed on the electrode patterns 2 and 4 or to be desorbed therefrom.

When the sealed state of the disperse system 7 is maintained as a discontinuous phase by the sealing member 5 provided along the edge portion in the above-described manner, the nonuniformities in the electric field strength brought about by factors such as variations in the distance between the two electrode patterns 2 and 4 will cause the electrophoretic particles 6 to move parallel to the surface of the electrode patterns, and will create a bias in the concentration distribution of the electrophoretic particles. The resulting drawback is that the concentration of electrophoretic particles becomes locally nonuniform and that display irregularities develop when such an electrophoretic display device is repeatedly used for a long time.

In view of this, structures in which a porous spacer 8 provided with numerous through-pores is used to seal a disperse system in the through-pores, and the disperse system 7 is thereby divided into a discontinuous phase among cells have been proposed as a means of overcoming such drawbacks, as shown in Fig. 4 (JP (Kokai) 49-32038, 59-34518, 59-171930, and the like).

**(Problems Which the Invention Is Intended to Solve)**

A substrate film disposed between two electrode plates is used in the above-described prior art, which relates to an electrophoretic display device with a divided disperse system, that is, to a device in which a disperse system is divided into a discontinuous phase among cells with the aid of a porous spacer. In such a device, there is a risk that the electrophoretic particles will be distributed unevenly because gaps are apt to be formed between the porous spacer and the electrode plates by film deformation or the like. In addition, configuring the two electrode plates from substrates in the form of glass plates makes it necessary to maintain a certain relationship between the planarity of the glass plates and the thickness distribution of the porous spacer, whereby gaps form between the porous spacer and the electrode plates in certain areas, and it becomes difficult to prevent the electrophoretic particles from being unevenly distributed in this structure as well.

Cell structures can also be created by bonding the two electrode plates and the interposed porous spacer in advance, but it is extremely difficult to uniformly inject a disperse system into the pores of the porous spacer in such a system, and numerous other production difficulties are encountered when the disperse system is injected. In addition, there is still the risk that the disperse system will be incompletely injected in some areas and that display defects will develop, thus leaving many unresolved problems in terms of obtaining a highly reliable display device.

**(Means Used to Solve the Above-Mentioned Problems)**

The present invention provides an electrophoretic display device in which a disperse system is divided using a porous spacer, wherein this electrophoretic display device is configured such that the porous spacer is composed of an elastic member, and one of the electrode plates is composed of flexible material, making it possible to inject the disperse system into the pores of

the elastic porous spacer in a simple and reliable manner; and further provides a manufacturing method thereof.

For this reason, the electrophoretic display device of the present invention is constructed by dividing and sealing, in the form of a discontinuous phase, a disperse system obtained by dispersing electrophoretic particles via a porous spacer between a set of oppositely disposed electrode plates at least one of which is transparent, wherein this electrophoretic display device is configured such that the porous spacer is composed of an elastic member, one of the electrode plates is rendered flexible and capable of being brought into close contact with the elastic porous spacer, the other electrode plate is formed from a transparent rigid body, and the flexible electrode plate is partially bent toward the through-pores of the elastic porous spacer to allow the disperse system in the elastic porous spacer to be kept at a negative pressure by the elasticity of the spacer.

In the technique for manufacturing such an electrophoretic display device, a flexible electrode plate and a transparent rigid electrode plate obtained by forming the desired electrode pattern on one side of a film member and transparent glass plate, respectively, are first prepared; a disperse system containing dispersed electrophoretic particles is fed in excess to a flexible porous spacer disposed on the electrode pattern side of the rigid electrode plate; the flexible electrode plate is mounted on the elastic porous spacer such that the electrode pattern thereof faces the electrode pattern on the rigid electrode plate; pressure is applied to the top surface of the flexible electrode plate; the flexible electrode plate is brought into close contact with the elastic porous spacer in a state in which the elastic porous spacer is compressed to force out excess disperse system and to seal the disperse system in the pores of the porous spacer; and the sealed disperse system is kept in a state of negative pressure by the restoring force of the elastic porous spacer as such.

Another appropriate technique for manufacturing such an electrophoretic display device is one in which an elastic porous spacer that can be formed from one of the following materials is monolithically formed in advance with the transparent rigid electrode plate: natural rubber, synthetic rubber (such as silicone rubber, urethane rubber, fluororubber, or acrylic rubber), and the like.

**(Practical Examples)**

The present invention will now be described in further detail with reference to illustrated practical examples. In the first figure, 10 is a transparent glass plate that serves as a substrate for the transparent rigid electrode plate, with a desired electrode pattern 11 appropriately formed using tin/indium oxide or the like on the top surface thereof. An elastic porous spacer 12 for sealing the disperse system after dividing it among cells is mounted on the top surface of the rigid electrode plate. The porous spacer 12 can be obtained by a process in which a sheet material composed of natural rubber, synthetic rubber (such as silicone rubber, urethane rubber, fluororubber, or acrylic rubber), or the like is provided with a large number of through-pores using a punch, laser, or other means, and the punched sheet is integrated with the rigid electrode plate on the side on which the electrode pattern 11 is formed. Alternatively, a photosensitive resin can be applied to the electrode pattern 11, and through-pores can be formed in an arbitrary manner by etching or other chemical dissolution means.

In preferred practice, a bonding and affixing portion 12A (shown by hatching) devoid of the through-pores 12B is formed along the peripheral edge of the elastic porous spacer 12 to match the below-described flexible electrode plate, in addition to the large number of through-pores 12B being formed in the above-described manner for the purpose of dividing and sealing the disperse system, as shown in Fig. 2. A flexible electrode plate composed of a film substrate 13 and provided with an electrode pattern 14 on the surface that faces the electrode pattern 11 is mounted on the top surface of the elastic porous spacer 12. 15 is a pressure member whereby the disperse system 7 is sealed in the pores 12B of the elastic porous spacer 12 completely and without any voids by a process in which the disperse system 7 fed in excess to the pores 12B of the elastic porous spacer 12 is pressed from the top surface of the flexible electrode plate, and any excess of the disperse system 7 is forced out while the spacer 12 is compressed. At least one of gas, liquid, and solid can be appropriately used for the pressure member 15, and a steel roll is used in the example shown herein. 16 is an adhesive designed to fixedly bond constituent members to each other by the end portions thereof.

To fabricate an electrophoretic display device of the type in which the disperse system is divided in this manner, an elastic porous spacer 12 such as the one shown in Fig. 2 is formed on

the electrode pattern 11 of a rigid electrode plate comprising a transparent glass plate 10 and the transparent electrode pattern 11; a disperse system 7 prepared in advance by dispersing titanium oxide or other electrophoretic particles in an appropriate liquid dispersion medium ideally suited to display purposes is fed in excess (in the required amount or greater) to the elastic porous spacer 12 to completely cover the spacer 12 with the disperse system 7; and a steel roll 15 that acts as a pressure member is mounted on the top surface of the flexible electrode plate in a state in which the flexible electrode plate is superposed on the elastic porous spacer 12 such that the electrode pattern 14 thereof faces the electrode pattern 11 of the rigid electrode plate. The flexible electrode plate is firmly pressed against, and kept in close contact with, the elastic porous spacer 12 as a result of the fact that the roll 15 gradually applies elastic force from one end portion of the flexible electrode plate. The excess disperse system that has been overfed to the elastic porous spacer 12 is thus forced out of the pores 12B of the spacer 12, and the disperse system 7 is sealed in the pores 12B in a state in which the elastic porous spacer 12 is compressed by the elastic pressure applied by the steel roll 15. In addition, fixedly bonding together the external peripheral edges of the rigid electrode plate, elastic porous spacer 12, and flexible electrode plate with the aid of an adhesive 16 allows the divided and sealed disperse system 7 to be kept in a state of negative pressure in the pores 12B of the spacer 12 by the restoring force of the elastic porous spacer 12, making it possible to facilitate and accelerate the process of completely sealing the divided disperse system without any voids.

The elastic porous spacer 12 described herein can be appropriately formed by a method in which a large number of required through-pores is formed by punching, drilling, laser processing, or another means in silicone rubber or another material fashioned into a sheet, and the thickness thereof is then adjusted by hot pressing or another means to a level equal to or less than the gap between the two electrode plates. The through-pores 12B of the spacer 12 may be shaped as circular, rectangular, polygonal, or any other pores besides angular, slitted, or the like, and may be arranged in a regular or irregular manner. The thickness of the elastic porous spacer 12 can be appropriately selected with consideration for the recovery properties of the member to be used (silicone rubber, urethane rubber, or the like), the composition of the disperse system, the gap between the electrode plates, and the like, and is commonly set between about 20 μm and 1 mm.

Various organic and inorganic pigments, dyes, ceramics, resins, and other fine powders or the like can be appropriately used in addition to the various known colloid particles as the electrophoretic particles of the disperse system 7. Various natural and synthetic oils and the like can also be arbitrarily used in addition to hydrocarbons, halogenated hydrocarbons, aromatic hydrocarbons, and the like for the dispersion medium of the disperse system 7. Dispersants, lubricants, stabilizers, and the like can be appropriately added as needed to the disperse system 7 besides electrolytes, surfactants, metal soaps, and electric charge control agents composed of particulate resins, rubber materials, oils, varnishes, compounds, and the like. It is also possible to adequately adjust the viscosity of the dispersion medium, the adsorption of electrophoretic particles on the electrode patterns 11 and 14, and other parameters in addition to adopting means whereby the electric charge of the electrophoretic particles is made uniformly positive or negative, or the zeta potential thereof is enhanced.

A working example entailed preparing a flexible electrode plate and a rigid electrode plate on which the desired transparent electrode patterns 11 and 14 were separately formed using tin/indium oxide on one surface of the film substrate 13 and transparent glass plate 10, and mounting a silicone rubber sheet having a large number of through-pore onto that side of the rigid electrode plate on which the electrode pattern 11 was formed to produce an elastic porous spacer 12 configured as shown in Fig. 2.

Hexyl benzene (100 cc) was prepared as the dispersion medium of the disperse system 7, 1 g of a dark blue dye composed of Oil Blue BA and 0.5 g of a surfactant composed of Silvan S83 were dissolved therein, and titanium oxide (5 g) was dispersed as electrophoretic particles in the solution, yielding a disperse system 7. The disperse system 7 was poured in excess onto the elastic porous spacer 12 to prevent any air from remaining, and the spacer was completely covered. The flexible electrode plate was subsequently mounted on the elastic porous spacer 12 in the manner shown in Fig. 1, and pressure was gradually applied from one end to the surface side of the flexible electrode plate with the aid of a steel roll 15, whereby any excess of the disperse system 7 was forced out while the flexible electrode plate was brought into close contact with the elastic porous spacer 12, and the disperse system was completely sealed in the through-pores 12B of the spacer 12 while the spacer was kept in a compressed state, whereupon clamping was accomplished along the peripheral edges of the flexible electrode plate in close contact with

the spacer 12. Finally, an epoxy adhesive 16 was used to fixedly bond together the end portions of structural members that included the two electrode plates and the elastic porous spacer 12 in the clamping portions, yielding an electrophoretic display device in which the disperse system 7 was divided among cells and sealed in a state of negative pressure (Fig. 1).

A dc voltage of 70 V was repeatedly applied between the electrode plates of the electrophoretic display device, and switching tests were performed, but the electrophoretic particles were observed to be free from bias, and highly contrast display operations could be performed even after 10, 000,000 switching cycles.

**(Merits of the Invention)**

The electrophoretic display device pertaining to the present invention is constructed by sealing a disperse system after dividing it as a discontinuous phase among cells with the aid of a porous spacer, wherein this electrophoretic display device is configured such that the porous spacer is composed of an elastic material, so when the display device is manufactured, a flexible electrode plate is mounted on the elastic porous spacer supplied with an excess amount of the disperse system, and pressure is gradually applied in this state to the flexible electrode plate, whereby any excess of the disperse system is forced out while the flexible electrode plate is kept in close contact with the elastic porous spacer, and the disperse system is sealed completely and readily in the through-pores of the elastic porous spacer without any remaining voids while the spacer is kept in a compressed state.

The disperse system sealed in the through-pores can be kept sealed by the restoring force of the elastic porous spacer in a state of negative pressure.

This type of electrophoretic display device has a simple structure and is ideally suited to the complete sealing of a disperse system in the through-pores of an elastic porous spacer.

It is thus possible to provide an excellent electrophoretic display device that is obtained by dividing the disperse system, is free from display defects, and has high contrast and display reliability.

## 4. Brief Description of the Drawings

Fig. 1 is a diagram depicting an electrophoretic display device of the type in which the disperse system is divided and in which a flexible electrode plate and an elastic porous spacer on a transparent rigid electrode plate are provided in accordance with a practical example of the present invention such that the disperse system is fed in excess to the elastic porous spacer, the flexible electrode plate is mounted, and the disperse system is sealed under the application of pressure to the flexible electrode plate as a technique for sealing the disperse system in the pores of the elastic porous spacer;

Fig. 2 is a structural diagram in the form of a fragmentary enlarged plan view schematically depicting an elastic porous spacer provided with a bonding and affixing portion on the side on which an electrode pattern is formed on the transparent rigid electrode plate in accordance with the method of the present invention;

Fig. 3 is a structural diagram in the form of a cross-sectional view schematically depicting an electrophoretic display device of the type in which the disperse system is a continuous phase configured in a conventional manner without the use of a porous spacer; and

Fig. 4 is a structural diagram in the form of a schematic cross-sectional view that depicts a conventionally configured electrophoretic display device of the type in which the disperse system is divided through the use of a porous spacer, and that illustrates the problems encountered when the disperse system is injected.

1, 3: transparent glass plates
2, 4: electrode patterns
5: end spacer
6: electrophoretic particles
7: disperse system used for display purposes
8: porous spacer
10: transparent glass plate
11: electrode pattern
12: elastic porous spacer

12A: bonding and affixing portion

12B: numerous through-pores

13: film substrate

14: electrode pattern

15: steel roll

16: fixing adhesive

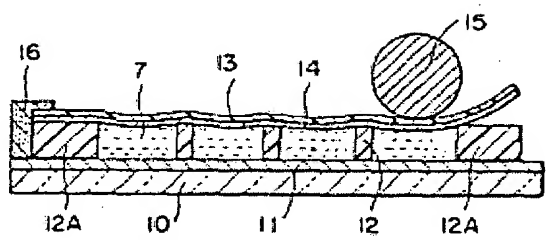


Fig. 1

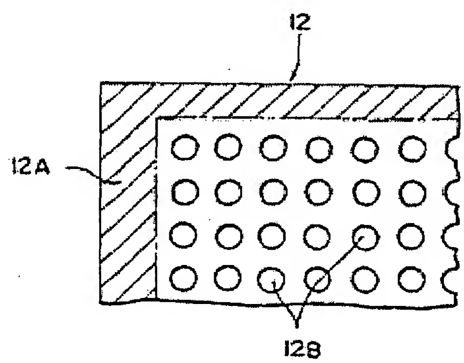


Fig. 2

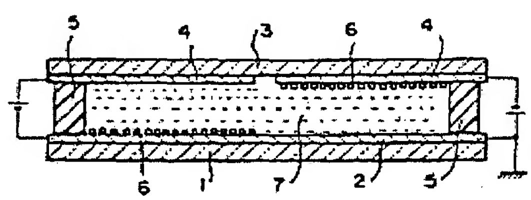


Fig. 3

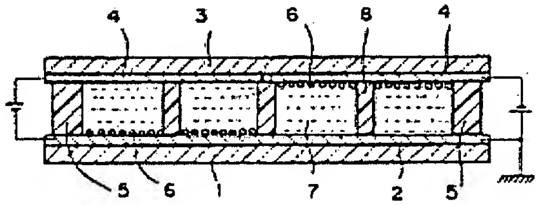


Fig. 4

Continued from p. 1

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